ELECTRICAL SAFETY IN DESIGN FINAL REPORT

Electrical mishaps have resulted in injury and death to Service members as well as DoD Civilians and Contractors. Electrical installation and equipment fires have been the primary contributor to property loss in deployed environments as well as in Civilian occupied buildings CONUS. New technologies and applications, including solar photovoltaic power systems, tactical microgrids, and electrical vehicles will increase exposure to electrical hazards to a broader range and greater number of untrained workers and warfighters. Safe design is critical to protect them, as well as our facilities and equipment. Using proven safe design strategies, the DoD Electrical Safety Working Group (ESWG) developed safe design tools to guide design, evaluation for acceptance, and acquisition for DoD's equipment, facilities, ships, solar photovoltaic systems, and electric vehicles to reduce the probability of failure. Work was completed between November 2012 and September 2015.

An example of the impact of safe design is the ground fault circuit interrupter (GFCI); since the technology has been integrated into portable tools and appliances in the USA, electrocutions have decreased 70%. DoD's new Electrical Safety in Design tools will have similar impact. Formatted as checklists, each has been vetted by technical experts as well as contracting organizations, and has been successfully tested on actual projects. Requirements which form the basis of each checklist are based on Codes and Standards and DoD and Services guidance in force in 2014. The checklists have been successfully integrated into specifications, procurements, design evaluations, and acceptance testing, and are already in use by the Military Services and Defense Agencies.

By assuring that electrical systems and equipment are designed to function effectively in the environments of use, safety in design is an important contributor to the likelihood of mission success. Members of the ESWG are grateful for the support and interest of the Defense Safety Oversight Council and the DoD Personnel Readiness leadership that fostered the development of the safe design products and enhanced electrical safety in DoD, the Military Services, and Defense Agencies. The products include:

A: Equipment

- Appendix A-1: Electrical Safe Design of Equipment Checklist
- Appendix A-2: DoD and Services Requirements Specific to Electrical Safety in Design for Equipment
- Appendix A-3: Electrically Safe Equipment Links -- Worldwide Listings Websites
- Appendix A-4: Safe Electrical Equipment Worldwide

B: Facility Electrical Systems

- Appendix B-1: Business Case for Electrically Safe Design of Facilities
- Appendix B-2: Technologies that Reduce Likelihood of Injury from Electrical Hazards Including Shock, Arc Flash, and Fire
- Appendix B-3: Electrical Safe Design of Facilities Checklist
- Appendix B-4: Electrical Safe Facility Design, Reliability, and Maintainability Checklist
- Appendix B-5: Facility Electrical Systems Inspection Checklist

- Appendix B-6: Importance of Quality Assurance for Equipment and Systems Critical to Electrical Safety

C: Watercraft

- Appendix C-1: Watercraft Electrical Safety Requirements, Policies, and Instructions
- Appendix C-2: Watercraft Electrical Safety Design, Reliability, and Maintainability Checklist
- Appendix C-3: Design Options for Watercraft Electrical Systems to Reduce Electrical Hazards and Improve Operability
- Appendix C-4: Applying Lessons Learned from Land-Based Systems to Watercraft Safe Electrical Design
- Appendix C-5: Watercraft LED Lighting

D: Electric Vehicle (EV)

- Appendix D-1: Electric Vehicle Safety Resources for Electrical Safety in Design
- Appendix D-2: Electric Vehicle Safe Design Checklist
- Appendix D-3: Electric Vehicle Battery Charger Safe Design Checklist
- Appendix D-4: Safety Considerations for Electric Vehicles

E: Photovoltaic Arrays (Solar Farms)

- Appendix E-1: Electrical Safety on Solar Farms
- Appendix E-2: Solar Photovoltaic Electrical Safe Design Checklist
- Appendix E-3: Solar Photovoltaic Electrical Hazard Evaluation Checklist

Along with the safe design products, the ESWG developed:

- Electrical hazard awareness training for non-electrical workers – important because most electrical fatalities occur to those who are not trained electricians.
- An electrical mishap investigation form to guide collection of information needed to identify the causes beyond human factors. The form is available at: https://navalforms.documentservices.dla.mil/web/public/home.

Since its inception in 2009, ESWG members have also contributed to technical solutions for important issues:

- Assisted the Joint Staff in creating guidance for safe interface with low hanging electrical distribution lines, and developed hazard specific electrical safety awareness training for forces deployed in Afghanistan.
- Refocused man pack radio research to include antenna insulation to prevent further electrocutions to deployed forces.
- Developed the Electrical Hazard Classification Mobile Application e-Tool, found at the following link: http://apps.ctc.com/esafe-pro/, to allow identification of previously unrecognized electrical hazards in equipment, weapon systems, and facilities, as well as provide specific guidance for work control for both Civilian and Military applications.
- Analyzed and identified cause of over 1,000 DoD electrical mishaps and developed specific prevention strategies.

- Reviewed technical content and requirements of 18 electrical safety military services technical and policy documents, some of which were decade's old, and provided recommendations to document owners to reflect current requirements and effective practices for safe electrical work.
- Identified deficiencies in Military Services' and Defense Agencies' programs for technical training of electrical workers and electricians, and developed appropriate training materials.

In addition to specific product development assignments, ESWG members met monthly via teleconference to discuss mishaps and lessons learned related to existing as well as emerging technologies, share best practices, and learn important electrical safety requirements and practices. Nationally renowned experts participated, as well as guest speakers. Monthly topics addressing emerging electrical safety issues and associated best practice solutions included: Training; Electrical Safety in Design; Batteries; Personal Protective Equipment (PPE); Codes, Regulations, and Guidelines; Mishap Reporting; Equipment; Facilities; Maritime; Photovoltaic Systems; Microgrids; and Overhead Power Lines. Technical presentations and materials presented between 2010-2014 have been archived on a SharePoint site maintained by Concurrent Technologies Corporation (CTC). Access to the site is available by contacting the WG chairs: Ms. Nancy Vyas, the U.S. Army Research Laboratory (ARL), Adelphi, MD, (nancy.h.vyas.civ@mail.mil), or Ms. Joy Erdman, Naval Safety Center Pentagon Liaison Office, Washington, D.C. (joy.erdman@navy.mil).

An active ESWG membership included representatives from Military Services and Defense Agencies, other government agencies, industry, and experts from the private sector.

ESWG Working Group Organizations	
Army • Army Forces Command, 11th Signal Brigade, Fort Hood, TX • Army Logistics Readiness Center • Army South • Headquarters, Department of the Army (HQDA) • Mobile Electric Power Project: U.S. Army • U.S. Army Armament Research, Development and Engineering Center (ARDEC) • U.S. Army Communications-Electronics Command (CECOM) • U.S. Army Communications-Electronics Research Development and Engineering Center (CERDEC) • U.S. Army Corps of Engineers (USACE) • U.S. Army Cyber Command (USCYBERCOM) • U.S. Army Installation Management Command (IMCOM) • U.S. Army Natick Soldier Research, Development and Engineering Center (NSRDEC) • U.S. Army Network Enterprise Technology Command (NETCOM) • U.S. Army Prime Power School and deployed military electricians • U.S. Army Research, Development, and Engineering Command (RDECOM) • U.S. Army Research Laboratory (ARL) • U.S. Army Safety Center • U.S. Army Training and Doctrine Command (TRADOC) • U.S. Army Training Support Center (ATSC) **Marine Corps** • U.S. Marine Corps Base Camp Lejeune, NC • U.S. Commandant, Marine Corps Headquarters CMC Safety Division (CMC SDSAFETY) • U.S. Marine Corps Installations East (MCIEAST) • U.S. Marine Corps Training and Education Command (TECOM)	**U.S. Navy** • Naval Education and Training Command (NETC) • Naval Facilities Engineering Command (NAVFAC) (Headquarters, Southwest Region and Public Works) • Naval Facilities Engineering and Expeditionary Warfare Center, Port Hueneme, CA • Naval Safety and Environmental Training Center • Naval Sea Systems Command (NAVSEA) • Naval Submarine Base (SUBASE), Kings Bay, GA • Naval Surface Force Atlantic (SURFLANT) • Naval Surface Forces, U.S. Pacific Fleet (SURFPAC) • Naval Surface Warfare Center (NSWC) Dahlgren Division • U.S. Fleet Cyber Command (FCC) • Naval Construction Battalion Forces ("SEABEES") • Naval Fleet Readiness Center Southwest • Commander, **Naval** Air Force Atlantic • Military Sealift Command (MSC) • Naval Safety Center • Puget Sound Naval Shipyard and Intermediate Maintenance Facility, Bremerton, WA **Air Force** • U.S. Air Force Civil Engineering Support Agency (AFCESA) • U.S. Air Force Institute of Technology (AFIT) Civil Engineer School U.S. Air Force Joint Base Charleston Support Squadron Force Support Squadron (FSS) 628th • U.S. Air Force Reserve Command (AFRC) U.S. Air Force Safety Center (AFSEC) • U.S. Air Force Vandenberg Air Force Base (AFB)

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